Note on the value of Danish Electricity and District heating distribution grids

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The aim of this small working paper is to estimate the value of the existing Danish electricity and district heating grids and the cost of expanding them. The purpose is to provide data for including such costs in the comparison of different scenarios of transforming the future national energy system.

The capacities of existing distribution grid infrastructures are here described by their proven capacities, i.e., how much energy has been delivered to the consumers in a peak hour.

For the Danish electricity distribution grid, such peak hour value is measured by the Danish TSO and has stayed on approx. 6000 MW for the last decade [1].

The Danish district heating grid consists of around 400 separate grids of which a few of the large systems are connected by transmission lines. Hourly peak demand measurements exist for some of the systems but there is no coordinated measurement to detail the exact coordinated maximum hourly deliverance of all systems. In accordance with Danish Energy Statistics [2], the maximum annual demand in recent years appeared in 2010, which was a relatively cold year in Denmark. In this year the demand for district heating was 150,393 TJ [2] equal to 41.8 TWh or an average of 4,800 MW. Based on a typical hourly distribution and duration curve, with a correlation between the average and the peak of a factor 2.81, the proven capacity of the Danish district heating grid can be estimated to approximately 13,000 MW.

Value of the electricity distribution grid

An estimate of the value as well as the cost of expanding the electricity distribution grid in Denmark is based on the following considerations:

- In 2015 the consumer payment for distribution of 33 TWh was in average approx. 28 EUR/MWh equal to a total of nearly 1 billion EUR/year. Assuming a lifetime of 50 years and an interest rate of 3%, and O&M equal to 1%, the capital value can be estimated to 20 billion EUR.
- Investments in the distribution grid in 2015 was 0.2 billion EUR. Assuming a lifetime of 50 years, this ends up in a capital value of 10 billion EUR or less. However, the investments were low in 2015 compared to previous years.
- An evaluation based on current standard prices of what it would cost to establish a complete new distribution grid, gives an estimate of 140 billion DKK equal to approx. 19 billion EUR.
- The Danish technology catalogue [4] uses a cost factor of 110-220 EUR/kW to assess investments in the electricity grid when increases in demand are investigated. This leads to grid values as low as 0.5-2 billion EUR.

Based on the above, the situation seems to be that minor increases in the demand can be done with just minor investments while a doubling or more of the demand would take investments in the order of magnitude similar to the capital value.

Here the above information has been put into cost-curves as shown in fig. 1. The curves assume a fixed cost of 5 and 10 Billion EUR respectively and relative costs so that the cost of the current distribution grid is 20 Billion EUR. The use of two curves illustrate the uncertainties related to these estimates.

Fig. 1: Investment cost of electricity distribution grids as a function of the peak load in MW. The current grid in Denmark represent a peak load of 6,000 MW corresponding to an investment of 20 Billion EUR.

Value of the District heating distribution grids

While the expansion of the electricity grid (in the study of future scenarios) represents a general increase of the supply and is relative to the peak-load, the district heating distribution grid is in a different situation. The district heating grids connect to approx. 50% of the consumers in Denmark and an expansion will involve new connections to the remaining houses. However, typically the more buildings one connects the higher per unit price. The Danish Technology catalogue [4] lists the cost of a complete grid in terms of EUR per MWh/year and the cost varies from 150 in dense urban areas to 700 in new areas with attached houses.

In 2008, the study "Heat Plan Denmark" [5] made a detailed analysis of the cost of expanding the district heating from 46% in 2006 to a potential future status of 70% of the Danish heat demand, coming to the following numbers:

- Expansion from 46% (27.9 TWh) to 52% (31.6 TWh) equal to 8 BDKK or 2,160 MDKK/TWh.
- Expansion from 52% (31.6 TWh) to 62% (37.6 TWh) equal to 25 BDKK or 4,170 MDKK/TWh.
- Expansion from 62% (37.6 TWh) to 70% (42.3 TWh) equal to 45 BDKK or 9,570 MDKK/TWh.

Average from 46 to 70%, equal to 5,400 MDKK/TWh or 720 EUR per MWh/year, which corresponds well with the cost of new areas mentioned above.

In the meantime, the district heating has expanded to more than 50% and today the supply is approx. 35 TWh. Based on the average number above, this equals a total investment of 150-200 BDKK or approx. 25 BEUR. However, the number might be lower since existing district heating typically includes a high share of

dense urban areas. Assuming an average cost of 400 EUR per MWh/year, the total investment cost of the existing grid is approx. 15 Billion EUR.

In a recent update of the Danish technology catalogue, it is differentiated between the cost in urban areas (150 EUR in investment per MWh/year heat demand) and suburban areas (655 EUR/MWh/year). A GIS analysis of the existing grids leads to the result shown in Table 1~~Table 1~~. As can be seen, the combination of these costs and the GIS analysis leads to a total of around 15 Billion EUR.

Table 1: Assumed investment cost for all Danish district heating systems. Based on a GIS analysis of the heat demand within urban and suburban area combined with specific grid investment costs from the Danish Energy Agency

Area type	Specific grid cost	End-use heat demand	Total grid cost
	EUR/MWh/year	TWh/year	BEUR/year
Urban	150	10.21	1.53
Suburban	655	21.04	13.78
Sum		31.25	15.31

Based on the above numbers and considerations, the cost curve shown in fig. 3 is made. The value of the current grid is set to 15 billion EUR and the cost of expansion is based on the estimates of "Heat Plan Denmark". However, to take the cost of the study from 2008 to now, all numbers are increased by 20% except for the estimate of investment costs of the current grid since it might already be a little too high. The costs beyond the 70% coverage are not accurate. It is added just to imply that after this point the costs will increase significantly.

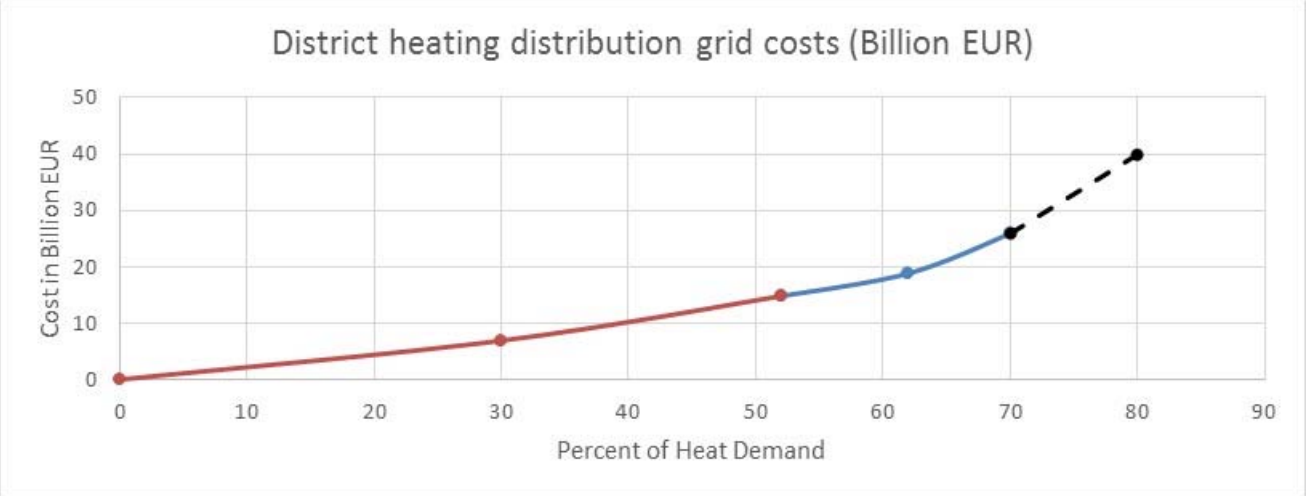

Fig. 2: Investment costs of district heating distribution grids as a function of the percent of Danish heat demand. The current grid in Denmark represents an annual average demand of approx. 35 TWh/year corresponding to an investment of 15 Billion EUR.

References:

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